Chapter 3. Background Information

This chapter focuses on the existing conditions in the project area. Sections of the chapter describe the existing environment, the demographics and land uses, the existing wastewater system, CSO characteristics, and the receiving water characteristics.

3.1. Existing Environment

This section describes the existing environmental conditions that could be affected by construction and operation of the Denny Way / Lake Union CSO Control Project. The study area has been generally divided into two sub-areas: south Lake Union and Elliott Bay. The existing environmental conditions have generally been characterized according to those two areas. A more complete discussion of the existing environment can be found in the *Denny Way/Lake Union Combined Sewer Overflow Control Project: Phases 2, 3, & 4 - Draft SEPA SEIS/NEPA EA* (King County, et al., 1997).

3.1.1. Earth Resources

The project area is located on the eastern shore of Puget Sound, between the Cascade Range to the east and the Olympic Mountains to the west. The project area's topography, soils, and surface geology are the result of the most recent Puget Sound region glaciation (Vashon), which occurred about 15,000 years ago. Four distinct geologic units are present in the area. Soils are largely derived from glacial and post-glacial deposition but are highly variable due to the urbanized nature of the area. Glacial deposits are located near the surface at higher elevations in the eastern and western portions of the south Lake Union area and are encountered deeper at lower elevations. Areas near Lake Union reflect more recent deposits such as alluvium, colluvium, and artificial fill. Soils in the Elliott Bay area include fill and soils derived from glacial till, outwash, and glaciolacustrine beds. The geologic hazards in the area mainly consist of erosion, seismic hazards, landslide, and slope instability.

Contaminated soils and / or sediments could be present along some of the alternative conveyance routes. Potentially contaminated soils are primarily located in the more industrialized areas of Seattle. Sediments with elevated levels of contaminants are known to exist in Lake Union adjacent to CSO and stormwater outfalls. Potential sources of contaminants to Elliott Bay include stormwater, CSOs, port activities, atmospheric deposition, industrial discharges, and the Duwamish River. Contaminants have been identified in sediments along Elliott Bay's central waterfront, particularly adjacent to CSO and stormwater outfalls.

3.1.2. Air Resources

The Puget Sound area has a typical marine climate with prevailing moisture-laden winds originating from the Pacific Ocean. This phenomenon, combined with the mountainous terrain, creates relatively high annual precipitation, ranging from approximately 30 to well over 40 inches annually in the Seattle area.

Sources of odors in the study area include vehicular emissions, industrial discharges, and emissions from wastewater facilities. The primary sources of air pollutants in both the south Lake Union and Elliott Bay areas are automobile emissions from roadway traffic and commercial and light industrial traffic. In the Elliott Bay area, the Denny Way regulator station is an occasional odor source, particularly in warm weather. Odor receptors include occupants of nearby buildings, passing motorists, pedestrians, and Myrtle Edwards Park users.

3.1.3. Water Resources

Lake Union and Elliott Bay comprise the major water bodies located within the study area. Lake Union is approximately 581 acres (235 hectares) in area. Elliott Bay, for purposes of this project, is defined as the water body east of a line between Fourmile Rock and Alki Point.

Elliott Bay is a tidally influenced marine water body. The inner portion of the bay is designated as “Class A (Excellent)”, and the outer portion of the bay is designated as “Class AA (Extraordinary)”. The classification for the inner bay reflects the heavily developed nature of the waterfront. Lake Union is designated as “Lake Class”.

Both Lake Union and Elliott Bay occasionally fail to meet surface water quality standards. The primary sources of pollutant loadings to Lake Union and Elliott Bay are from discharges of industrial wastewater, marina and boat waste, CSOs, and stormwater.

Detailed information on the quantity and quality of groundwater resources in the study area is limited. Most groundwater is found perched on glacial till in sand and gravels associated with glacial outwash deposits. Groundwater recharge is limited by the extensive coverage of pavement and buildings. It is likely that groundwater near Elliott Bay is tidally influenced and located at shallow depths.

3.1.4. Biological Resources

In general, plant resources in both the Lake Union and Elliott Bays areas are those typically found in urbanized, landscaped settings. Such plants include ornamental plantings, native and non-native grasses and weeds, and street trees. There are no known occurrences of any federally-, state-, or locally-listed sensitive, threatened, or endangered plant species within the study area. Wetland adapted plants occur within the project area along the shoreline in South Lake Union Park. Aquatic plants occur within Lake Union itself in near shore and shallow habitats. Eelgrass and kelp beds are important plant communities found in the aquatic marine environment of Elliott Bay.

Wildlife species inhabiting the area are anticipated to be limited to those species exceptionally tolerant of human intrusion and development. Numerous waterfowl exist along the shorelines of Lake Union and Elliott Bay. No federal or state-listed sensitive, threatened, or endangered wildlife species are documented to occur within the project area according to the Washington Department of Fish and Wildlife database; however, bald eagles are a federal and state-listed threatened species which have been documented using Lake Union for foraging and fishing. Bald eagles, peregrine falcon, and marbled murrelets are federally listed threatened and endangered species that have been observed foraging in and around Elliott Bay. Marine mammal haulouts for harbor seals and sea lions are located on Harbor Island and near West Point. Stellar sea lion, harbor seal, killer whale, and river otter have been observed in Elliott Bay.

Anadromous fish runs were altered in Lake Union with the construction of the Lake Washington Ship Canal in 1916. Anadromous salmonid species, including sockeye, chinook, and coho salmon, and cutthroat and steelhead trout primarily use Lake Union as a migratory passageway. Resident warm water fishes, including yellow perch, squawfish, largemouth bass, black crappie, and brown bullhead, inhabit Lake Union throughout their life cycles. Shellfish inhabiting Lake Union include crayfish, which serve as prey species for fish and, to a small degree, are harvested recreationally. Lake Union is designated as a "usual and accustomed" fishing area for the Muckleshoot Tribe.

The most abundant marine fish species in Lake Union include several species of sole, starry flounder, sculpin, perch, herring, hake, smelt, cod, and pollock. Salmonid species use Elliott Bay and the Duwamish River as a migration corridor to upstream spawning habitat in the Green River basin. Elliott Bay is an important sport fishing area for salmon and other marine fish. Identified shellfish in the bay include geoduck, clam, crab, and shrimp.

3.1.5. Energy

Electrical energy is supplied to the study area by Seattle City Light. Washington Natural Gas Company provides natural gas service to the area. Power supply is discussed in more detail in Section 3.1.12 – Public Services and Utilities.

3.1.6. Environmental Health

Public health risks can occur through the transmission of pathogens, which are present in CSOs, to receiving waters that are used for recreational purposes, including swimming (limited in Elliott Bay due to cold water), scuba diving, wading, and fishing. Pathways for potential exposure include direct contact with contaminated water (e.g., swimming, wading), ingestion of pathogen-containing water, and/or ingestion of contaminated fish or shellfish. Commercial harvest of shellfish is prohibited in Elliott Bay, and recreational harvest of shellfish is not recommended due to the high levels of fecal coliform bacteria. Pathogens of particular importance when considering CSOs include bacteria and viruses that are present in untreated wastewater. Potentially toxic constituents (e.g., petroleum products, metals) that are transported in stormwater also present potential health risks. Hazardous material spills during construction pose a threat to workers, as well as to surface and groundwater quality.

Bacterial loading to Lake Union is a potential environmental health concern because of the high amount of recreational use in the lake and along the shoreline, including swimming, wading, kayaking, and sailing.

3.1.7. Noise

The human ear responds to a wide range of sound intensities. Factors affecting the impact that a given noise will have on a person include frequency and duration of the noise, the absorbency of the ground and surroundings, and the distance of the receptor from the noise source. The receptor and the usual background noise levels also influence the degree of impact. Traffic sound is one of the major sources of noise in both the south Lake Union and Elliott Bay areas. In the south Lake Union area, sea planes represent a significant noise source. Potential noise receptors in the south Lake Union area include businesses, residences, and pedestrians. Noise receptors in the Elliott Bay area include users of Myrtle Edwards and Elliott Bay Parks, businesses along Elliott Avenue, and condominium residents along the southwestern slope of Queen Anne Hill.

3.1.8. Parks and Recreation

Three City-owned parks are located in the south Lake Union area. The 5-acre Denny Park features benches, broad pathways, tall trees, and a grassy lawn. The 14-acre South Lake Union Park features the Maritime Heritage Center, picnic tables, benches, and lake access. The 1.7-acre Cascade Playground features one swingset, one children's play structure, and one ballfield.

Six parks are located in the Elliott Bay area. The City-owned, 3.7-acre Myrtle Edwards Park and the adjoining Port of Seattle-owned, 10.5-acre Elliott Bay Park feature two separated 1.25-mile paths for bicycles and pedestrians, beach access, benches, and a grassy lawn. The Port of Seattle-owned Elliott Bay Fishing Pier offers tables, benches, shelters, and fish cleaning stations. Fourteen-acre Kinnear Park features large grassy areas, broad pathways, benches, and a tennis court. The Port of Seattle-owned, 0.4-acre Smith Cove Park offers shoreline access, picnic tables, and grassy areas. The 77-acre Seattle Center includes 20 acres of open space, the Space Needle, Pacific Science Center, numerous stadiums and theaters, and an amusement park.

All of the parks are heavily used, particularly the waterfront parks and the Seattle Center.

3.1.9. Aesthetics

The project area is highly urbanized. Development is mostly medium to high density commercial. Views in the area are dominated by the surrounding physical features, including the Olympic and Cascade mountain ranges, and water bodies including Puget Sound, Lake Union, and Lake Washington. Much of the area's development has been oriented to take advantage of the scenic nature of the area.

The southern end of Lake Union offers views of the highly developed Lake Union shoreline, downtown Seattle, and surrounding commercial land uses. The Elliott Bay area offers views both of and from the Space Needle, Elliott Bay, southern Puget Sound, downtown Seattle, the Olympic Mountain Range, and Mount Rainier.

3.1.10. Historical and Cultural Preservation

Historic structures associated with different stages of Seattle's development are numerous throughout the project area; over two hundred historic structures and historic properties are in or adjacent to the project area, including residences, apartments, churches, businesses, and schools.

Portions of the project area have a high probability for hunter-fisher-gatherer and/or historic archaeological resources, especially the old shoreline of Lake Union and Elliott Bay. Hunter-fisher-gatherer archaeological resources consist of the remains of occupations of people inhabiting the Seattle area prior to contact with Euroamericans and could include base camps, seasonal camps, villages, sweat lodges, burial sites, and cemeteries.

3.1.11. Transportation

The study area contains complex street, marine, and rail transportation networks. The areas that could be affected by project construction include some of the most heavily used transportation networks in Seattle. Interstate 5 (I-5), running north-south, skirts the eastern edge of the south Lake Union area, and State Route 99 runs along the western edge. The south Lake Union area is connected to the Elliott Bay area by Mercer Street and Denny Way, which run east-west. These areas are especially congested due to their access to limited entry points on I-5. Elliott Avenue West parallels Elliott Bay and is a major route for truck traffic to and from the area's port.

King County Metro Transit operates the bus system in both the south Lake Union and Elliott Bay areas. Transit routes serve the major streets throughout the area. The area around Lake Union and the Elliott Bay waterfront are popular pedestrian and bicycle routes. In addition, bicycle lanes are available on some of the area streets in each of the project areas.

Lake Union is a recreational boating center with some industrial usage. The lake is used extensively by kayaks, canoes, and small watercraft, as well as being a major sea plane hub. Harbor facilities in Elliott Bay are extensive and support a wide variety of commercial and recreational traffic including cargo vessels, local and international ferry vessels, and pleasure boats.

The Burlington Northern Santa Fee Railroad (BNSFRR) owns and operates rail lines throughout the Seattle area. BNSFRR owns a rail line the entire length of Lake Union, although the south Lake Union area is less developed than the Elliott Bay area in terms of rail traffic. The Elliott Bay waterfront has an intricate and highly used rail system. Access to shipping piers and waterfront facilities has produced an infrastructure of rail lines spanning the entire waterfront with a major rail yard located east of Terminal 91. Amtrak trains operate on BNSFRR rail lines and depart from the King Street Station in Pioneer Square. In addition, King County Metro Transit owns and operates a trolley system that has regularly scheduled trips along the waterfront.

3.1.12. Public Services and Utilities

Electrical energy is supplied to the project area by Seattle City Light. Power is distributed from major substations, via high voltage feeder lines, to numerous smaller distribution stations and pole transformers. A major substation, the Broad Street substation, is located within the south Lake Union area. Denny Way is the location of a major underground transmission arterial, as is Alaskan Way. The waterfront area between Massachusetts Street and Denny Way is served by an underground transmission network.

The Seattle Water Department serves retail customers of Seattle and portions of King County. Water distribution lines are located under most streets in the project area, including streets proposed for alternative locations.

Seattle Solid Waste Utility contracts with private firms for the collection of residential and commercial garbage, recyclables, and yard waste within Seattle. The Solid Waste Utility provides for disposal of all garbage generated within Seattle, including construction waste.

Washington Natural Gas Company provides natural gas service to Seattle. High pressure gas mains are located along Westlake Avenue North, Battery Street, and Elliott Avenue West. Local distribution mains are located in most major streets in the project area.

Seattle's Drainage and Wastewater Utility (DWU) is responsible for the collection of wastewater within Seattle. The DWU system collects residential, commercial, and industrial wastewater and delivers it to interceptor lines operated by King County. Wastewater collected from the study area is treated at King County's West Point Treatment Plant. Collector sewer lines ranging from four to twelve inches in diameter are located under most streets in the project area. The Elliott Bay interceptor runs parallel to the railroad tracks along Elliott Bay and conveys wastewater to the West Point Treatment Plant. Because much of Seattle's wastewater collection system was constructed near the turn of the century, many combined sanitary/stormwater sewers exist.

3.1.13 Sensitive Areas

According to the *Sensitive Areas Mapfolio* (1990), there are no floodplains or shoreland wetlands in the project area along south Lake Union or Elliott Bay. The coastal zone areas for both water bodies are restricted to the immediate shorelines. The potential for natural historic landmarks and historic and archaeological sites in the project area was described in the Historical and Cultural Preservation section (Section 3.1.10) above. There are no threatened plant species present in the project area. Threatened wildlife species include bald eagle in the south Lake Union area and bald eagle, peregrine falcon, and marbled murrelet in the Elliott Bay area. Impacts to these species as a result of this project are expected to be minimal. According to the *King County Comprehensive Plan* (1994), there are no areas of prime and unique farmlands in the project area.

3.2. Population and Land Use

This section provides a population and housing profile for both the City of Seattle as a whole and the project area. Much of the housing and population data were obtained from the 1990 U.S. Census. It should be noted that the boundaries of the seven census tracts in the vicinity of the project area that were analyzed for this report do not coincide with the boundaries of the project area.

3.2.1. Population

The population of Seattle has fluctuated since 1970, while much of the remainder of the region experienced steady and sometimes rapid growth. The City's population declined between 1970 to 1990; however, between 1990 and 1995 the City's population increased by 3.2 percent to an estimated 532,900. The median age for Seattle residents was 34.9 years according to 1990 census data. Even with increasing in-migration of individuals with various ethnic backgrounds, Seattle's population is predominantly of Caucasian origin.

Population in the project area increased during the 1980 to 1990 time frame. The 1990 estimated population of the study area was approximately 37,650 and is estimated to be approximately 44,100 by the year 2000. As with Seattle as a whole, the population of the project area is predominantly Caucasian.

3.2.2. Land Use

Land use patterns in the south Lake Union and Elliott Bay areas typify urban levels of development and reflect historic land use patterns in Seattle. Current development in the south Lake Union area is a combination of industrial, commercial, and residential uses. Warehouses, parking lots, and offices characterize most of the area. Land use around the Lake Union shoreline is currently in transition from what was historically industrial manufacturing use to commercial and residential uses, including restaurants, marinas, and houseboats.

The Elliott Bay area includes several Seattle neighborhoods. Land use is mostly residential in the Queen Anne neighborhood. Other uses include commercial and light industrial areas along Elliott Bay and the Denny Regrade neighborhood of downtown. Current land use in the Denny Regrade neighborhood is characterized by high density office and residential buildings with ground floor retail use.

Seattle contains a mix of single-family neighborhoods and areas of high density, multifamily, residential development. Approximately 49 percent of Seattle's housing units are owner-occupied. Since the late 1980s, rents and home prices in Seattle have generally increased at a higher rate than income level, and housing affordability has become a problem.

In 1990 there were approximately 15,200 housing units in the project area, with the highest density of residential housing located on Queen Anne hill. More housing is located in Queen Anne neighborhoods than along Lake Union. Housing along Lake Union consists of a few apartments and houseboats on the lake. Housing in the project area is older than in Seattle as a whole, with almost half of all units having been constructed before 1939.

3.3. Existing Wastewater System

King County (County) currently maintains the largest wastewater conveyance and treatment system in the Pacific Northwest, providing sewage conveyance and treatment services to 33 cities, sewer districts, and other agencies serving more than one million people. Two secondary treatment plants, the West Point Treatment Plant and the East

Section Reclamation Plant (ESRP) at Renton, operate continuously to treat all base sewage flows generated within the King County system. An additional plant at Carkeek Park provides primary treatment to CSOs during storm events. Another plant at Alki is being converted to a CSO treatment plant as well. All King County treatment plants discharge to Puget Sound pursuant to National Pollutant Discharge Elimination System (NPDES) permits.

Wastewater generated by individual customers is collected in smaller branch sewers which are owned and maintained by cities and sewer districts. These local collection systems discharge to King County trunk sewers and interceptors. King County is contractually obligated to maintain interceptors to receive these flows. The County is thus a "wholesale" wastewater conveyance and treatment agency, and its municipal and agency customers, including the City of Seattle, are "retail" agencies.

Typical of the era in which they were planned and built, Seattle's sewers were designed to carry both sanitary and storm flows. These combined sewers were adequate during the early part of this century, but increased development has produced dramatically increased sewer flows and taxed the capacity of the existing system. As a result, the existing system is not able to handle all the wastewater being channeled to it during periods of prolonged or heavy precipitation so common in the Pacific Northwest, causing combined sewer overflows.

King County's existing wastewater conveyance and treatment system serving the Denny basin project area consists of the wastewater treatment plant at West Point, the Elliott Bay interceptor, the Interbay pump station, the Denny Way regulator station and CSO outfall, the Lake Union tunnel, and the Dexter regulator station. Figure 3-1 shows the location of King County's wastewater facilities serving the Denny basin. The City of Seattle operates a collection and conveyance system around the east and south shores of Lake Union that collects combined wastewater and discharges it to the County's Lake Union tunnel. City CSOs in the Lake Union area discharge wastewater to the lake when flows exceed the capacity of the Lake Union tunnel. Figure 3-2 shows the location of the City of Seattle wastewater facilities that serve the Lake Union area.

3.3.1. West Point Treatment Plant

The West Point Treatment Plant, located adjacent to Discovery Park in Seattle's Magnolia neighborhood, was commissioned in 1964. The West Point service area includes nearly all of the City of Seattle and parts of unincorporated King County north of Seattle. The plant also receives flows from southern Snohomish County. All of the Denny

Way / Lake Union project area lies within the West Point service area. Until recently, the West Point plant provided primary treatment for an average design flow of 125 million gallons per day (mgd) and a peak, wet-weather flow of 300 mgd.

The West Point Treatment Plant was recently expanded and began full secondary treatment operation in 1995. The plant provides secondary treatment for peak wet weather flows up to 300 mgd. The treatment processes include screening, grit removal, primary sedimentation, high purity oxygen activated sludge biological treatment, secondary clarification, disinfection with chlorine in a chlorine contact channel, and dechlorination.

Influent flows between 300 and 440 mgd are considered CSO flows and receive primary treatment, consisting of screening, grit removal, primary sedimentation, disinfection with chlorine in chlorine contact channels, and dechlorination. When flows are above 300 mgd, the primary and secondary effluents are blended prior to discharge through the outfall. All flows are disinfected and dechlorinated prior to discharge into Puget Sound through a 240-foot-deep, 3,600-foot-long outfall with diffuser.

The removed primary and secondary solids are blended and co-thickened with gravity belt thickeners, anaerobically digested, and dewatered by centrifuges.

The existing flows and the design flows to the West Point plant are summarized in Table 3-1. The average wet weather flow with storms was 133 mgd at West Point in 1996, and 136 mgd in 1997. The average non-storm wet weather design flow is 133 mgd. The actual non-storm wet weather flows were not available. Average dry weather flows were 98 mgd (1996) and 105 mgd (1997), slightly below the design dry weather flow of 110 mgd. Average annual flows were 117 mgd (1996) and 121 mgd (1997), are also below the design annual average capacity of 142 mgd. Maximum month flows were 167 mgd and 168 mgd in 1996 and 1997 respectively, below the 215 mgd design maximum month capacity.

Table 3-1. West Point Treatment Plant Capacity

Parameter	**Design conditions** [a]	**1996**	**1997**
Flows (in million gallons per day)			
Average dry weather (May through October)	110.1	98	105
Average wet weather non-storm (November through April)	133.0		
Average wet weather (Including storms)		133	136
Maximum month	215	167	168
Maximum secondary flows	300		
Peak combined sewer flows	440		

BOD (pounds per day)			
Maximum month	54,000	27,000	45,000
Total suspended solids (pounds per day)			
Maximum month	81,000	60,000	30,000

[a] Design loadings from *Addendum to the March 1989 West Point Facilities Plan*, October 1990, Municipality of Metropolitan Seattle.

Table 3-2 lists the January 1, 1996, NPDES limitations for West Point.

Combined sewage primarily travels to the West Point Treatment Plant by way of the north interceptor, the west Duwamish interceptor, and the Elliott Bay interceptor. King County's computer augmented treatment and disposal system (CATAD) is another important component of the West Point wastewater conveyance system. The CATAD system serves to regulate flow to the plant and to maximize storage capacity in existing sewers throughout the West Point service area. One important objective of CATAD is to minimize CSOs from the system. CATAD monitors and controls various pumps and regulator gates. Flow data is transmitted from flow monitoring locations throughout the system to the main control center at West Point. The computer is programmed to use incoming information to make decisions regarding how to best manage the volume of wastewater flow. If flows exceed the allowable flow rates at designated points within the system, key regulator gates are closed and pump station flows are curtailed in a sequence designed to store flows where capacity is available.

Table 3-2. West Point NPDES Effluent Limitations[a]

Parameter	Average monthly	Average weekly
BOD_5 and TSS (November through April)		
Concentration	30 mg/L	45 mg/L
Mass discharge	54,000 pounds/day	81,000 pounds/day
BOD_5 and TSS (May through October)		
Concentration	30 mg/L, or 15 percent of monthly average influent, whichever is more stringent	45 mg/L
Mass discharge	54,000 pounds/day	81,000 pounds/day
Fecal coliform	200 colonies/100 mL	400 colonies/100 mL
pH	Shall not be outside the range 6.0 to 9.0	
Total residual chlorine	217 µg/L, 387 pounds per day	546 µg/L

Cyanide[b]	21 µg/L, 38 pounds per day	42 µg/L

[a] Maximum effluent limitations for flows or waste loads as stated in the *NPDES West Point Permit No. WA-002918-1*, January 1996, Department of Ecology.

[B] Cyanide limit can be removed after 12 months of sampling, should the cyanide concentration be consistently less than 10 µg/L.

3.3.2. Elliott Bay Interceptor

The Elliott Bay interceptor is a large sewer running north along the Seattle waterfront. The interceptor conveys sewage from downtown Seattle and the Duwamish and Denny basins to the north interceptor and eventually to the West Point Treatment Plant. During dry weather, the sewage from the Denny basin enters the interceptor at the Denny Way regulator station in Myrtle Edwards Park. The interceptor diameter is 102-inches at the point where the Denny basin flows enter the interceptor.

3.3.3. Interbay Pump Station

The Interbay pump station is located at the intersection of 15th Avenue West and Elliott Avenue West, just south of the east end of the Magnolia Bridge. The pump station is part of the Elliott Bay interceptor system, receiving flow from the Duwamish pump station and from all the regulator stations located on the Elliott Bay interceptor, including the Denny Way regulator station. Interbay also receives wastewater from the trunk sewer serving the Magnolia neighborhood. Wastewater is pumped from Interbay through two 48-inch force mains into the north interceptor and to the West Point Treatment Plant. Pumping capacity at the pump station is 128 mgd, provided by three pumps (two service, one backup). Standby electric power is provided by a natural gas/propane-powered generator. A project to upgrade Interbay pump station to 133 mgd is due to be completed by the end of 1998.

The Interbay pump station has no overflow discharge. When the north interceptor reaches capacity, pumping at Interbay may be curtailed or shut down. Then flows in the Elliott Bay interceptor begin to back up and overflows into Elliott Bay occur upstream at the Denny Way regulator station.

3.3.4. Denny Way Regulator Station and Outfall

The Denny Way regulator station consists of two separate regulators, the Denny local and Denny/Lake Union regulators, within a single regulator station building. The Denny Way regulator station is located in Myrtle Edwards Park, along the Seattle waterfront near the downstream end of the Elliott Bay interceptor. Under storm conditions, CSOs are controlled from three different weir heights within the regulator station. The Denny/Lake Union flows are controlled by means of a weir set at 111.5 feet (1988 Metro datum). The Denny local flows are controlled by means of a weir set at Elevation 107.0 feet. At times, when the Elliott Bay interceptor is at capacity, flows are discharged at an emergency weir near the Denny Way regulator station set at Elevation 99.56 feet. Upstream regulators and the Duwamish pump station are operated to maximize flows into the interceptor. As a consequence, there is little capacity in the interceptor at Denny Way, resulting in frequent overflows.

Figure 3-3 is a flow schematic of the Denny Way regulator station. Wastewater enters the regulator station from the 42-inch-diameter Denny local trunk sewer or the 60-inch-diameter Lake Union trunk. Flows from both trunks are combined in a short, 30-inch-diameter line leading to the Elliott Bay interceptor.

There are three different overflow scenarios that can take place at the Denny Way regulator station. These scenarios are as follows:

1. The Elliott Bay interceptor is running full by the time it reaches the Denny Way regulator station. As a result, Denny / Lake Union and Denny local flows have no place to go except over their respective overflow weirs, through their outfall gates, and out the outfall.

2. The Elliott Bay interceptor has additional capacity, but the volume of wastewater coming down the 60-inch Denny / Lake Union pipeline and 42-inch Denny local pipelines is so great that the 30-inch-diameter pipe cannot handle the flows. As a result, wastewater backs up in the pipelines and some of the wastewater spills over the overflows weirs and out the outfall.

3. Regardless of the flows coming down the Lake Union tunnel or Denny local pipelines, the flow in the Elliott Bay interceptor from upstream sources may exceed the capacity of the Interbay pump station downstream from the regulator station. In addition, emergency conditions at West Point may require that the flow from the Interbay pump station be throttled back from its peak capacity. In either case, the Elliott Bay interceptor begins to back up until it reaches surcharged conditions at the Denny Way regulator station, where it overtops the emergency overflow weir and flows out the outfall.

Modeling in connection with the *1995 CSO Update* indicated that CSO discharges occur at the Denny Way regulator station more than 50 times per year. The average annual volume of combined wastewater discharged there was estimated to be about 405 MG in 1988. By the time the conversion of the Alki Treatment Plant to storm weather operation is complete, other system improvements are completed, and the Lake Union overflows are added to the Denny baseline flows in 1998, the average annual discharge will exceed 550 mgd. When overflows occur at the Denny Way regulator station, those overflows are discharged to Elliott Bay by means of a 96-inch-diameter outfall at the regulator station. The Denny Way CSO outfall is not a submerged structure and, during low tide conditions, the CSO effluent is discharged directly onto the beach adjacent to the regulator station and allowed to flow across the beach to the water. During higher tides, the outfall structure is partially or completely beneath the surface of Elliott Bay.

3.3.5. Lake Union Tunnel

The Lake Union tunnel collects and conveys sewage flows from around Lake Union to the Denny-Lake Union regulator. The tunnel is a 100-year-old, brick-barrel sewer, 72-inches in diameter at its upper end. The tunnel size is reduced to 60-inches in diameter about 450-feet upstream from where it enters the regulator station.

The Denny/Lake Union basin lies south of Mercer Street, east of the Seattle Center to the crest of Capital Hill. It covers approximately 492 acres. The east Lake Union basin lies east of the lake and north of Mercer Street, and includes approximately 430 acres. Wastewater from these two highly developed urban areas is carried to the eastern portal of the Lake Union tunnel, near the intersection of Terry Avenue and Republican Street. The tunnel conveys these combined Lake Union area flows under the Seattle Center to the Denny Way regulator station.

3.3.6. Dexter Regulator Station

The Dexter regulator station is located on the west side of Dexter Avenue North, just south of Galer Street. The station regulates flow in the central trunk sewer, which empties into the north interceptor. The regulator is intended to prevent backups into upstream service connections in Seattle's central business district and Denny Regrade areas. The regulator overflows into Lake Union during periods of high flow in the central trunk. Dexter discharges approximately 15 MG per year of CSO into Lake Union.

The Dexter regulator station consists of a hydraulically powered regulator gate with an invert set at an elevation of 135.34-feet, and a hydraulically powered bypass gate with an invert 2.5-feet higher than the regulator gate. An overflow weir in the Galer Street overflow chamber, immediately downstream of the regulator station, is set approximately 6 inches higher than the bypass gate (3 feet higher than the regulator gate). The station has a standby, diesel-powered generator to provide electrical power to the station during power outages.

3.3.7. City of Seattle's Lake Union Conveyance and CSO Control System

The City of Seattle's combined sewer that collects wastewater along the south and east sides of Lake Union drains approximately 430 acres. The area drains to a 2.7-mile-long sewer trunk, which eventually discharges to King County's Lake Union tunnel. There are eight uncontrolled CSOs at various places along the trunk, and these outfalls discharge approximately 86 MG per year of combined sewage to Lake Union. Phase 1 of the Denny Way/Lake Union CSO Control Project, which began construction in March 1996, involves upsizing the sewer trunk and abandoning several of the outfalls. However, until Phase 2 of the County CSO control facilities has been completed and the capacity needed to accept the city flows has been built, the City overflow volume to the lake will remain essentially unchanged. Even before Phase 2 of the County project is constructed, the additional conveyance capacity being provided in Phase 1 will provide enough storage to reduce or eliminate overflows during some of the smallest storms.

A complete description of the existing city sewer and drainage system can be found in the City of Seattle's *Phase 1 Facilities Plan*, filed in June 1995, and included in this report as Appendix A.

3.3.8. Denny Local Pipeline

The Denny local basin lies north of Denny Way and east of Elliott Avenue to about Queen Anne Avenue. The basin is made up of dense residential and some commercial and industrial properties. It includes about 232 acres of combined area. Flows from the basin enter the Denny Way regulator station by means of a 42-inch-diameter pipeline. The regulator station is equipped with a separate overflow weir and regulator gate for Denny local basin flows.

3.4. CSO Flows and Waste Loads

CSO flow volumes and the amount and characteristics of the pollutants in the combined sewer flows at the time overflows occur are two important factors in designing CSO treatment facilities.

3.4.1. 1988 Baseline CSO Flow Volumes

For the Metro *Final 1988 Combined Sewer Overflow Control Plan*, Metro and Ecology agreed that the CSO control system as it existed during the period 1981 to 1983 would be an appropriate baseline from which to measure CSO control progress. The term "baseline" refers to the physical characteristics of the collection and control system during the 1981 to 1983 period, as well as the volumes or frequencies of overflows which occurred during that period. The baseline condition was characterized by selecting seven actual storm events from 1981 to 1983 as design storms for calibrating a computer model of the combined sewer system. (See Chapter 10-, Subsection 10.1.1, for more information concerning the seven design storms.) The *1988 Plan* estimated annual overflow volumes for each Metro CSO discharge location, based on the characteristics of the seven design storms. Design Storm No. 6, which occurred from November 16 to 18, 1982, is particularly important because a CSO facility that will control overflows during Design Storm No. 6 is predicted to meet the Ecology goal of not more than one untreated overflow event per year.

The *1995 CSO Update* produced revised baseline overflow volumes that showed little difference in total overflow volume between the *1988 Plan* (2.409 billion gallons) and the *Update* (2.391 billion gallons). However, the CSO overflow volume changed significantly for certain CSO sites. The revised estimate of 1988 Denny Way annual CSO overflow volume was 405 million gallons.

3.4.2. CSO Waste Loads

King County historical CSO sampling data from 1988 through April 1996 for the following locations and facilities were analyzed to predict the influent CSO waste loads:

- CSO regulators (Denny Way, Brandon Street, Hanford, West Michigan, Chelan Avenue, 8th Avenue, Norfolk Street, Connecticut, Ballard, Montlake, Third Avenue West, and East Ballard).

- Carkeek Park and Alki Treatment Plants.
- West Point Treatment Plant.

The waste load information included total suspended solids (TSS) concentrations, flow volumes, and limited flow rate data. The regulator CSO data were limited to a dozen or fewer pieces of information, while the West Point and Alki Treatment Plant information contained several hundred daily data points.

There was insufficient data at any individual CSO site to establish a statistically significant relationship between flow volume and influent TSS concentration. The best correlation was obtained by combining historical data from the Carkeek Treatment Plant and the ten regulators. Figure 3-4 shows the historical CSO influent TSS concentration data for the regulators and Carkeek Park Treatment Plant. The historical data shows that lower TSS concentrations tend to be associated with higher CSO flows, while the TSS concentrations associated with lower volume CSO events vary considerably. The historical data indicates that the CSO influent TSS concentrations range from about 35 to 1,000 mg/L, with an average of about 160 mg/L and a median concentration of 125 mg/L. Preliminary results of CSO sampling of four storms, conducted during the spring of 1997, indicated that average influent TSS concentrations at the Denny Way regulator station amounted to about 90 mg/L during the four CSO events monitored.

3.5. Current West Point Treatment Plant Performance

The West Point Treatment Plant commenced full secondary treatment late in 1995. Table 3-3 summarizes the treatment plant performance compared to its discharge permit requirements and the 1991 Settlement Agreement.. The secondary treatment plant complied with its NPDES BOD and TSS effluent limits for both weekly and monthly requirements during 1996, and was well below the annual discharge limits set by the Settlement Agreement in both 1996 and 1997.

The monthly effluent BOD and TSS averaged 17 and 13 mg/L, respectively, well below the 30 mg/L monthly limit. BOD and TSS monthly mass discharge averaged 17,000 and 15,000 pounds per day (lbs/day) compared to the monthly effluent mass discharge limit of 54,000 lbs/day. Monthly BOD and TSS removal efficiency during the dry weather season (May through October) averaged 90 percent and 91 percent, respectively, compared to the monthly dry season permit requirement of 85 percent removal efficiency. Fecal coliform bacteria, pH, total residual chlorine and cyanide effluent levels were all below permit monthly average limits.

The weekly effluent BOD and TSS averaged 22 and 19 mg/L, respectively, well below the 45 mg/L weekly limit. BOD and TSS weekly mass discharge averaged 23,000 and 24,000 lbs/day compared to the weekly effluent limit of 54,000 lbs/day. Weekly fecal coliform bacteria levels were within permit limits except for one week. There were two daily maximum chlorine residual exceptions reported during 1996. However, there were no exceptions reported for the average monthly total chlorine residual concentrations and mass discharge limits.

The actual annual BOD discharged from the West Point facility was 6.2 million pounds in 1996 and 7.3 millions pounds in 1997; well below the 19.7 million pounds annual BOD discharge limit established by the 1991 Settlement Agreement. Similarly, in 1996 and 1997 TSS total annual discharge loadings were 5.4 million pounds and 5.7 million pounds respectively; also well below the 19.7 million pounds annual TSS discharge limit in the agreement.

3.6. Current West Point Biosolids Disposal Methods

All biosolids processing systems are on-site at the West Point Treatment Plant and include the following: raw sludge thickening, anaerobic sludge digestion, dewatering, privatized sludge processing, polymer storage, and a cogeneration facility to use excess digester gas. The County's biosolids management program involves beneficial reuse through silviculture, application to agricultural lands, and composting. The privatized biosolids management process will reuse biosolids through wholesale distribution of dried biosolids as a soil fertilizer. Additional digester capacity will be needed if the privatized biosolids management system does not successfully complete its primary biosolids operations phase. The County is currently evaluating the privatized biosolids management primary biosolids phase operations for compliance with its contract terms and conditions.

3.7. Untreated or Partially Treated Discharges

Untreated or partially treated discharges from the Denny Way / Lake Union system occur at the West Point Treatment Plant and at several CSO outfall locations within the project area.

Table 3-3. Summary of 1996 West Point Performance and NPDES Effluent Limits (January through December 1996)

NPDES Permit Parameter	NPDES Permit Limit	Annual Average	Value Maximum	Permit Exceptions
BOD$_5$ Concentration, mg/L				
Average monthly	30	17	22	0
Average weekly	45	22	32	0
BOD$_5$ Mass Discharge, pounds/day				
Average monthly	54,000	17,000	27,000	0
Average weekly	81,000	23,000	43,000	0
BOD$_5$ Monthly Reduction, percent				
Dry Weather(May through October)	85	91	86	0
Annual Average	None	90	86	N/A
TSS Concentration, mg/L				
Average monthly	30	13	22	0
Average weekly	45	19	37	0
TSS Mass Discharge, pounds/day				
Average monthly	54,000	15,000	36,000	0
Average weekly	81,000	24,000	64,000	0
TSS Monthly Reduction, percent				
Dry Weather (May through October)	85	95	91	0
Annual Average	None	92	82	N/A
Fecal Coliform Bacteria, colonies/100 mL				
Average monthly	200	23	108	0
Average weekly	400	180	1,526	1
pH	6.0 to 9.0	6.6 to 7.3	6.2 to 8.0	0
Total Residual Chlorine				
Average monthly, µg/L	216	75	108	0
Average monthly, lb/day	387	69	140	0
Maximum daily, µg/L	546	412	1,560	2
Cyanide				
Average monthly, µg/L	21	<5	5	0
Average monthly, lb/day	38	0.3	4	0
Maximum daily, µg/L	42	<5	10	0
Total Annual BOD Discharge				
1996 (million lb/year)	19.7*	6.2		
1997 (million lb/year)	19.7*	7.3		
Total Annual TSS discharge				
1996 (million lb/year)	19.7*	5.4		
1997 (million lb/year)	19.7*	5.7		

*Limit set by 1991 settlement agreement

3.7.1. West Point Treatment Plant

The plant provides primary treatment for flows in excess of 300 mgd (considered CSO flows). Flows are diverted to the chlorine contact basin, where the flows are blended with secondary effluent prior to discharge.

3.7.2. Combined Sewer Overflows

There are two King County CSO discharge locations in the project area. One discharge occurs through the existing outfall at the Denny Way regulator station (see Figure 3-1). The other discharge occurs at the Dexter regulator station. In addition, the City of Seattle collection and conveyance system has nine CSO outfalls within the project area. These City outfalls are shown on Figure 3-2.

3.8. Receiving Water Characteristics

WAC 173-201A designated Lake Union as "Lake Class" and the inner Elliott Bay as "Class A (Excellent)" The classification for inner Elliott Bay reflects the heavily developed nature of the waterfront, industry, and commerce in and surrounding Seattle. Despite the high water quality standards, Department of Health does not allow the harvest of shellfish or benthic algae in Elliott Bay's inner shoreline because of potential contamination.

3.8.1 Lake Union

Lake Union has been a Seattle industrial hub for more than 100 years. Numerous industries have operated in and around the lake including a coal gasification plant, power plant, asphalt manufacturing plants, lumber mills, sand, gravel and concrete producers, and shipbuilders. Current sources of pollution to Lake Union include industrial discharges, marina and boat wastes, CSOs, and stormwater. Following completion of Seattle's Phase 1 project, there will be three CSO sites (City of Seattle CSO 125 and 175 and King County Dexter regulator) discharging about 40 million gallons a year into Lake Union. In addition, there are 19 stormwater outfalls in the Lake Union/Ship Canal system.

Lake Union is seasonally stratified, with temperatures ranging from 43 °F throughout the water column in the winter to 66°F to 73°F in the surface waters during the summer. Dissolved oxygen ranges between 8 and 12 mg/L at the surface during the year and between 0 to 12 mg/L in deeper waters. Mesotrophic lakes, such as Lake Union, typically lack oxygen at depth for all or part of the summer to fall while the oxygenation of surface waters is at or near saturation throughout the year.

Lake Union has been classified as mesotrophic (moderately enriched) according to chlorophyll concentration, phosphorus concentration, secchi disk transparency, and phytoplankton community structure. Chlorophyll concentration (measure of algal productivity) ranges between 2 to 10 micrograms per liter (μg/L) with a long term median of 4 μg/L. Total phosphorus concentrations generally range between 15 to 30 μg/L. Nitrate and ammonia concentrations are high in the winter and decrease during the summer until they are below detection limits. There has been no apparent long-term trend since the mid-1970s in phosphorus or nitrogen concentrations.

The concentration of metals is generally low in Lake Union. Total copper concentration has exceeded the state freshwater acute toxicity criteria on a limited number of occasions, and total cadmium, copper, lead, and zinc concentrations have periodically exceeded the state freshwater chronic toxicity criteria. Organic compounds (phenol and benzoic acid) were detected at low concentrations at three sites in 1990, and PAHs and phthalates were detected at low concentrations near Gasworks Park. No state or federal freshwater criteria for PAHs are currently available.

Fecal coliform bacteria frequently exceed the state lake water quality criterion of 100 colonies per 100 mL during months with high precipitation. Periodically, high concentrations of fecal coliform bacteria have been attributed to CSO and stormwater discharge events. Since 1979, Lake Union has regularly meet or exceeded state water quality standards from November through February.

3.8.2 Elliott Bay

Elliott Bay has also been an industrial hub for more than 100 years. Past sources of contaminants to Elliott Bay include intensive industrial activities and discharges. Current sources of pollution to the bay include port activities, atmospheric deposition, industrial discharges, marina and boat wastes, CSOs, and stormwater. Ten existing CSO outfalls discharge a total volume of 3 billion gallons a year into Elliott Bay. Three of those outfalls are operated by King County. The largest CSO discharge remaining in the King County system is at the Denny regulator with an annual overflow volume of 405 million gallons. King County operates three wastewater treatment plant outfalls (Alki Point, West Point, and the ESRP outfall off the Duwamish Head) which discharge immediately outside of Elliott Bay. Each wastewater outfall has its own NPDES permit. In addition, there are 45 stormwater outfalls discharging into Elliott Bay, although no City-maintained outfalls are located along the central waterfront area.

In the summer, the water temperature is thermally stratified. The maximum water surface temperatures (57°F to 58°F) occur in August, and winter temperatures remain relatively constant (between 43°F to 46°F). During winter and spring, river discharge is high, and the surface waters in the plume of the Duwamish River have relatively lower salinities than the rest of Elliott Bay. Dissolved oxygen concentrations tend to be highest in the spring (10 mg/L), coincident with maximum phytoplankton production. Lower dissolved oxygen concentrations typically occur in the late summer or early fall, resulting from reduced productivity, decomposition of phytoplankton, and intrusion of low-oxygen, oceanic water.

Elliott Bay has relatively low productivity for floating algae and aquatic plants compared to many areas of Puget Sound because high concentrations of suspended solids contributed by the Duwamish River interfere with light transmission. Elliott Bay exhibits a thin (less than 16 feet) surface layer of suspended matter which is dominated by phytoplankton in the summer and inorganic particulates in the winter.

Despite the highly urbanized Seattle waterfront in Elliott Bay, toxic metals contaminants are found in relatively low concentrations in surface waters. Only zinc and iron were found regularly in surface waters at greater than 1 µg/L. Lead, chromium, nickel, and copper were all present, but were found at very low concentrations.

The fecal coliform bacteria concentrations in Elliott Bay are generally low, except in the winter months. Fecal contamination in intertidal areas appears to occur during periods of high rainfall, when river discharge and CSOs are at maximum flows. However, fecal coliform contamination is generally correlated less with location and more with exposure. Those beaches that are exposed to wind and waves tend to have lower levels of fecal coliform bacteria. The Seattle-King County Public Health Department does not recommend collecting shellfish for consumption from any urban marine beach. Although beaches along the Seattle waterfront tended to exceed the state shellfish growing standards during the winter months, offshore water column monitoring has shown relatively low fecal coliform bacteria contamination. Offshore monitoring stations exceeded standards less than 1 percent of the time in subsurface waters. In addition, sewage outfall monitoring has shown a steady, but non-significant, decline in fecal coliform bacteria levels since 1980.

3.9. Infiltration/Inflow Evaluation

The USEPA and Ecology have issued regulations intended to limit the effects of excess flows such as infiltration and inflow. These regulations require either reducing the flow values or providing at least primary treatment to those excess flows that cannot be economically conveyed and provided with secondary treatment.

An analysis is necessary for each project receiving USEPA grant funds to determine whether it is more cost-effective to exclude all or part of this extra flow or to provide capacity in the secondary treatment facility to accommodate it. It is stated in 40 CFR 35.2120 that inflow is not considered excessive in any event for combined sewers.

The Ecology regulations generally follow the USEPA regulations. The Ecology approach requires analysis for both infiltration and inflow on fully separated collection systems, but only infiltration is to be considered in combined basins. Inflow in combined sewer basins is to be evaluated as part of CSO control planning in accordance with WAC 173-245.

An infiltration/inflow analysis was performed for the West Point service area as part of the *March 1989 West Point Secondary Treatment Facilities Plan*. For the analysis, the entire West Point service area, except upstream of the Matthews Beach pump station, was considered to be a combined sewer system. Sewers entering the Kenmore lake line upstream of Matthews Beach pump station are separate sewers. The inflow analysis indicated that inflow at the Matthews Beach pump station was considered to be nonexcessive because the per capita flow rates were less than the USEPA threshold value of 275 gallons per capita per day for infiltration and inflow. A cost-effectiveness analysis for infiltration was performed to determine if infiltration removal would reduce annual CSO discharge volumes. Assuming a 30 percent infiltration removal rate, the estimated overall infiltration reduction for the West Point collection system is 12.2 mgd. It was predicted that the infiltration reduction would result in a total annual CSO volume reduction of 45.9 million gallons.

The cost of infiltration removal was then compared to the cost of the resulting CSO control facilities cost reduction. Since the cost of infiltration removal exceeded the resulting CSO control facility cost reductions, infiltration removal was determined to not be cost effective. Even if the assumed infiltration removal efficiency were doubled to 60 percent, infiltration removal would still not be cost effective.

The cost effectiveness of infiltration removal was then evaluated relative to the West Point Treatment Plant. The least total cost for treatment plant capital, operation and maintenance costs, and cost for infiltration removal was for no infiltration removal. Therefore infiltration removal relative to the West Point Treatment Plant was not cost effective.

3.10. Approved Ecology CSO Control Plan

The *1988 CSO Control Plan* was approved as Metro's CSO control plan by Ecology. King County is required by WAC 173-245-090 to periodically review its plan for controlling CSO volumes and frequencies to evaluate the progress toward meeting CSO control goals. The *1995 CSO Update* described the CSO control projects King County would undertake through the end of year 2005 to reduce CSO volume by 75 percent system wide from the 1988 baseline conditions. The *Update* estimated that the annual overflow volumes would be reduced from 2,391 MG a year in 1988 to 840 MG a year upon completion of the projects listed there.

Ecology has since waived the interim requirement of 75 percent volume control by 2006 in favor of an approach to scheduling CSO projects based on perceived risks to human health. As part of the negotiation for the waiver, King County committed to completion of projects already underway, including:

- Denny Way / Lake Union CSO Control Project
- Henderson / Martin Luther King Way CSO Control Project
- Harbor CSO Pipeline Project
- Alki Transfer / CSO Facilities

Table 3-4 lists the proposed CSO control projects that have been completed since the *1988 Plan* or are currently scheduled. King County is developing and scheduling additional CSO control projects as part of the Regional Wastewater Services Plan (RWSP) to achieve system-wide once per year control.

Table 3-4. King County CSO Control Projects

Project	Completion
Phase 1: Completed CSO control projects (1987-1991)	
South Hanford Street tunnel separation/Bayview storage	1987
Lander separation	1987
CATAD modifications	1991
Phase 2: Current CSO control projects (1992-1997)	
Carkeek Park transfer and CSO facility	1994
King Street storage	1994
Fort Lawton parallel tunnel	1993
University regulator separation	1995
Alki transfer/CSO facilities	1998
Phase 3: Complete by year 2001	
Harbor CSO pipeline	1998
Phase 4: Complete by year 2006	
Denny Way/Lake Union CSO control (Phase 4)	2006
Completion date to be determined in RWSP	
Henderson Street/Martin Luther King Way CSO control	2007
North Beach storage/pump station upgrade	
Brandon separation	